Hatches Harbor Salt Marsh Restoration: 2007 Annual Report

Stephen Smith, Kelly Chapman, Michelle Galvin, Evan Gwilliam, & John Portnoy

Cape Cod National Seashore

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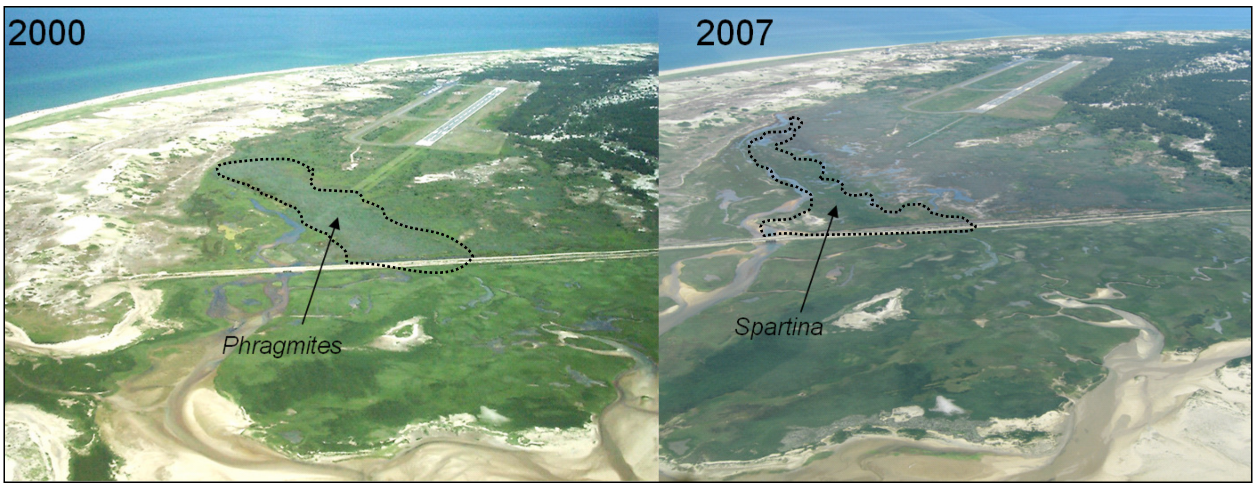

SUMMARY

- Tidal range landward of the Hatches Harbor dike averages 2.07 ft or about 57% of the range of the unrestricted marsh.
- Tide heights seaward of the dike have changed little since 2000.
- Phragmites continues to decline at low elevations near creeks that experience higher salinities; however, there were some plots where *Phragmites* had invaded since 2006 - generally at large distances away (upslope) from the tidal creek.
- Over the past seven years of tidal restoration, the restricted marsh has been colonized by nearly all native salt-marsh plants that are present in the unrestricted marsh, with substantial reestablishment of *Spartina* spp.
- Restored creeks have hastened the reestablishment of salt marsh plants by allowing their seeds and other propagules to penetrate farther onto the marsh plain.
- A prescribed burn, planned for winter 2007-8, of *Phragmites* and standing dead shrubs should promote the dispersal and spread of salt marsh plants.
- Nekton landward of the dike are dominated by mummichogs, reflecting improved fish access to the marsh plain, and sand shrimp, indicating sandier substrate in tidal channels.
- Monitoring of tide heights, porewater salinity, vegetation and nekton will continue in 2008.

INTRODUCTION

Environmental monitoring of the Hatches Harbor salt marsh has been undertaken annually by the National Park Service since 1997, and intensified with incremental tidal restoration beginning in 1999. This reports on tide heights, vegetation and nekton (fish and decapod crustacean) sampling conducted during 2007.

Because the Provincetown Municipal Airport occupies a portion of the historical coastal flood plain and derives some tidal flood protection from the Hatches Harbor Dike, tidal restoration has always been monitored and controlled to ensure continued protection of airport safety. In 2007, Seashore resource managers and Airport staff cooperated in assessing the effects of a recent breach in the earthen berm at the seaward (south) end of Runway 7 on water levels in the instrument-landing-system reflectance area. Although this study was not part of regular environmental monitoring, its observations, conclusions and related correspondence are appended for reference to this report (Appendix A).

1. TIDE HEIGHTS

Kelly Chapman

The basic objective of the Hatches Harbor Salt Marsh Restoration is to restore the tide-restricted wetland to the extent possible without compromising safety at the Provincetown Municipal Airport. In order to meet this objective, NPS has monitored tide heights since 1997, and the system's response to incremental tidal restoration since March 1999. This section focuses on tidal height data that were collected in the summer of 2007 at two locations within this salt marsh system.

Methods

In previous years, tidal height data were collected by YSI6000 and YSI6600 multi-parameter data loggers. Since May 2005, HOBO water level recorders were used. The instruments were then deployed in existing stilling wells that were established in 2005. They were deployed at two locations:10 m seaward of the dike structure (unrestricted side), and about 500 meters upstream of the structure on the restricted marsh side (Figure 1-1). The existing upstream station had been covered by sand, therefore making it difficult to deploy; therefore, this station was moved approximately 10 m towards the dike.

Data were uploaded at the end of a 2-month period. Temperature and absolute pressure (including atmospheric pressure and water head) were recorded by the instruments at 15-minute intervals. Once the data were uploaded, observed water levels were corrected for atmospheric pressure changes , using the accompanying HOBO software, and converted to elevations in feet relative to NAVD88.

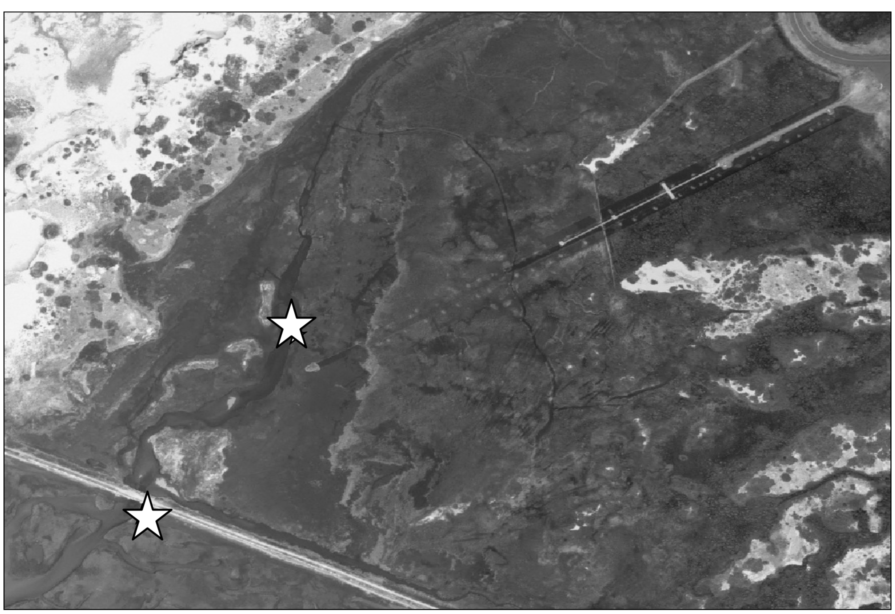

Figure 1-1. Hatches Harbor salt marsh showing tide gauge locations.

Results & discussion

The final 20-cm increase in culvert opening in June 2005 continues to yield little increase, over the culverts' prior setting, in mean high- and low-tide heights and in tidal range (Table 1-1). Tidal range in the restricted marsh was 2.07 ft, as opposed to about 3.66 ft in the unrestricted marsh seaward of the dike.

Table 1-1. Mean high and mean low tide heights (ft) and tidal ranges (ft-NAVD-88) from three tide gauge locations in Hatches Harbor.

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Station	**Mean High**	**Mean Low**	**Tidal Range**
Unrestricted			
October 2003 - June 2005	4.98	1.50	3.48
June 2005 – August 2005	4.78	1.44	3.35
June 2006 – October 2006	4.75	1.21	3.54
August 2007 – October 2007	5.49	1.83	3.66
Restricted			
October 2003 - June 2005	4.32	2.12	2.2
June 2005 – August 2005	4.29	1.99	2.30
June 2006 – October 2006	4.26	2.16	2.10
August 2007 – October 2007	4.56	2.49	2.07
Airport			
October 2003 - June 2005	2.52	1.96	0.56
June 2005 onward	3.93	3.30	0.63
March – April 2007	3.95	3.87	0.08

Data collected during August and September 2007 indicate the dampening effect of the dike and culvert system (Fig 1-2). High tides remain lower and low tides higher in the restricted, than in the unrestricted marsh. This is likely due to the combined impedance of the structure (albeit fully open) plus a shallow sill in the main creek between the culverts and the "restricted" data logger 500 m upstream, which restricts low-tide drainage. As in 2006, 2007 tidal range is about 57% of downstream tidal forcing, as compared to only 26% prior to new culvert installation (Table 1-1 and Fig. 1-5). Meanwhile there has been little change in tidal forcing on the seaward side of the dike since at least 2000 (Fig. 1-4).

Figure 1-2. Tide heights just seaward of (unrestricted), and 500 m upstream of (restricted) the Hatches Harbor dike in summer 2007. The dashed horizontal line marks the critical ILS flooding threshold of 10 ft-MLW (4.58 ft-NAVD-88) established by the Federal Aviation Administration in 1987.

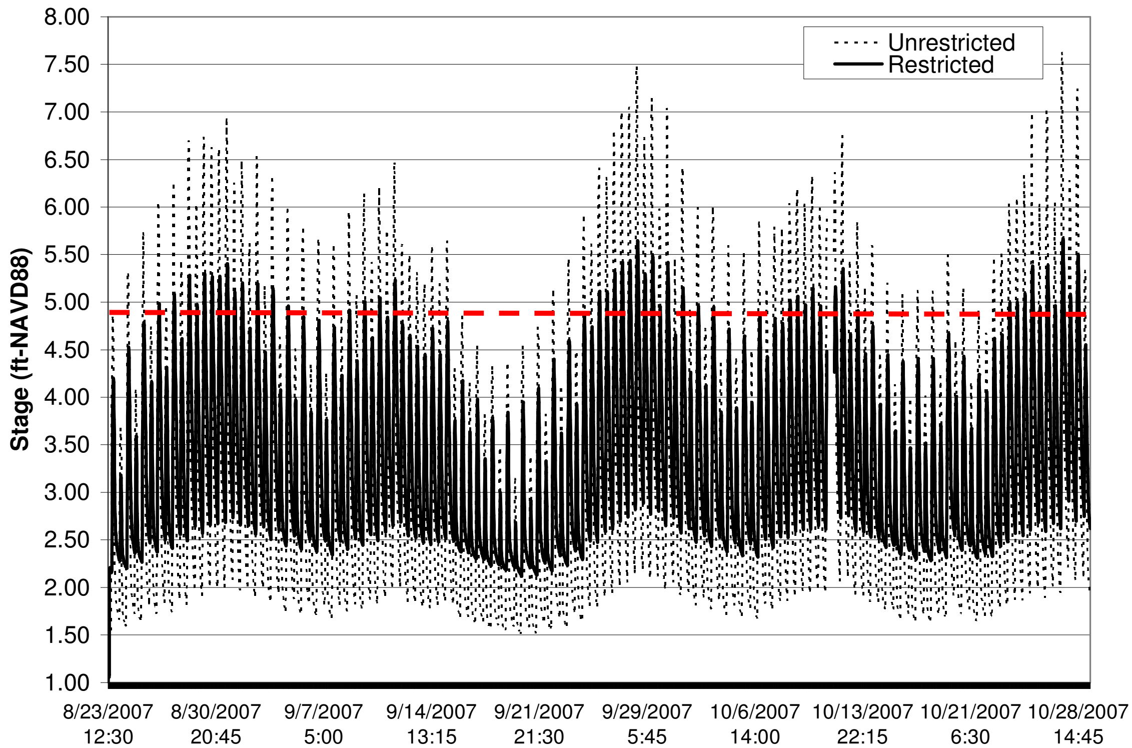


Figure 1-3. Mean high, mean low and mean tidal ranges from tide gauges just seaward (unrestricted) and 500 m landward (restricted) of the Hatches Harbor dike in 2007.

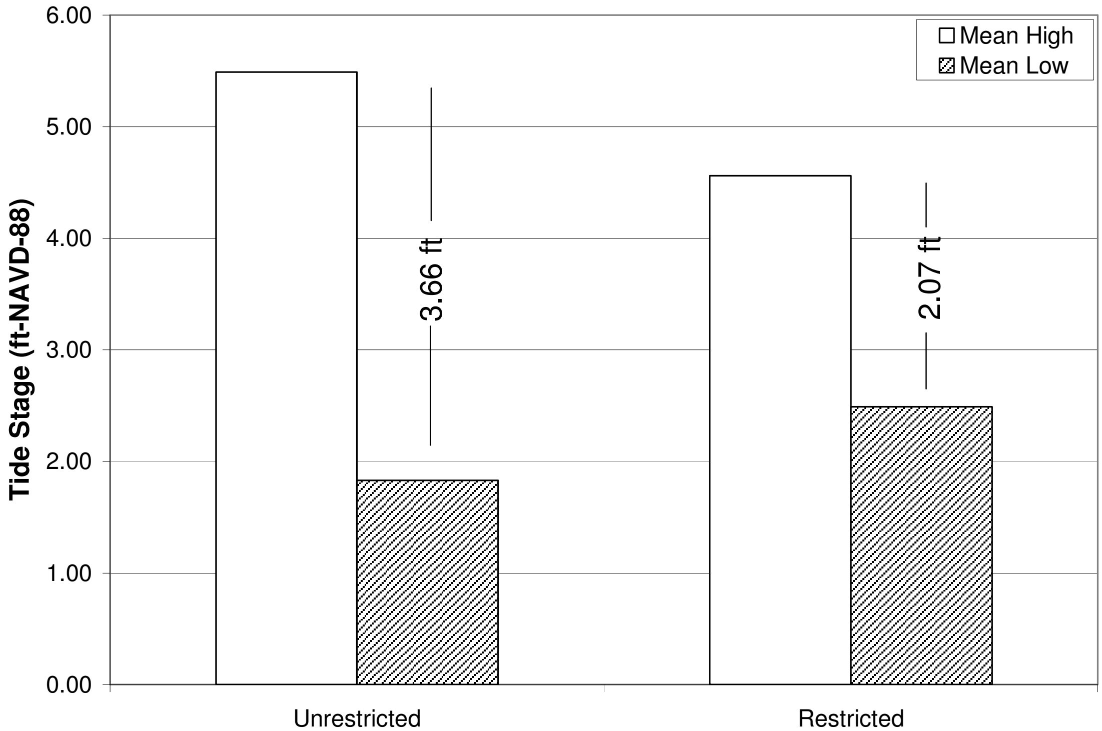


Figure 1-4. Mean high- and low-tide heights and tidal ranges in unrestricted Hatches Harbor seaward of the dike, 1998-2007.

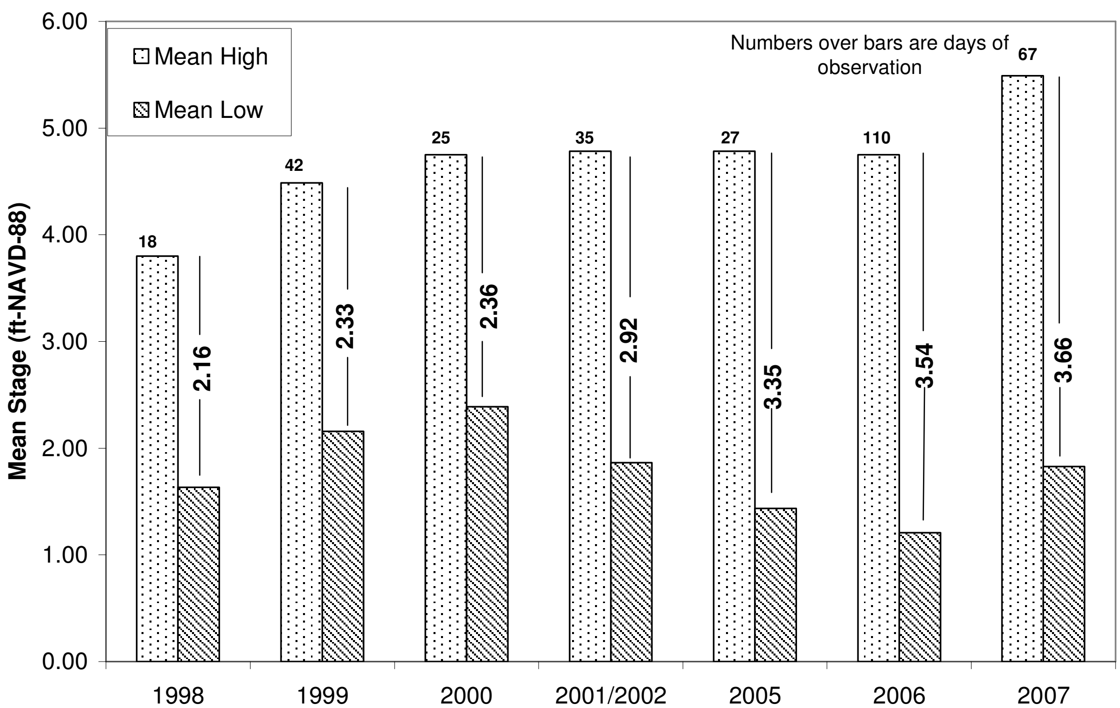
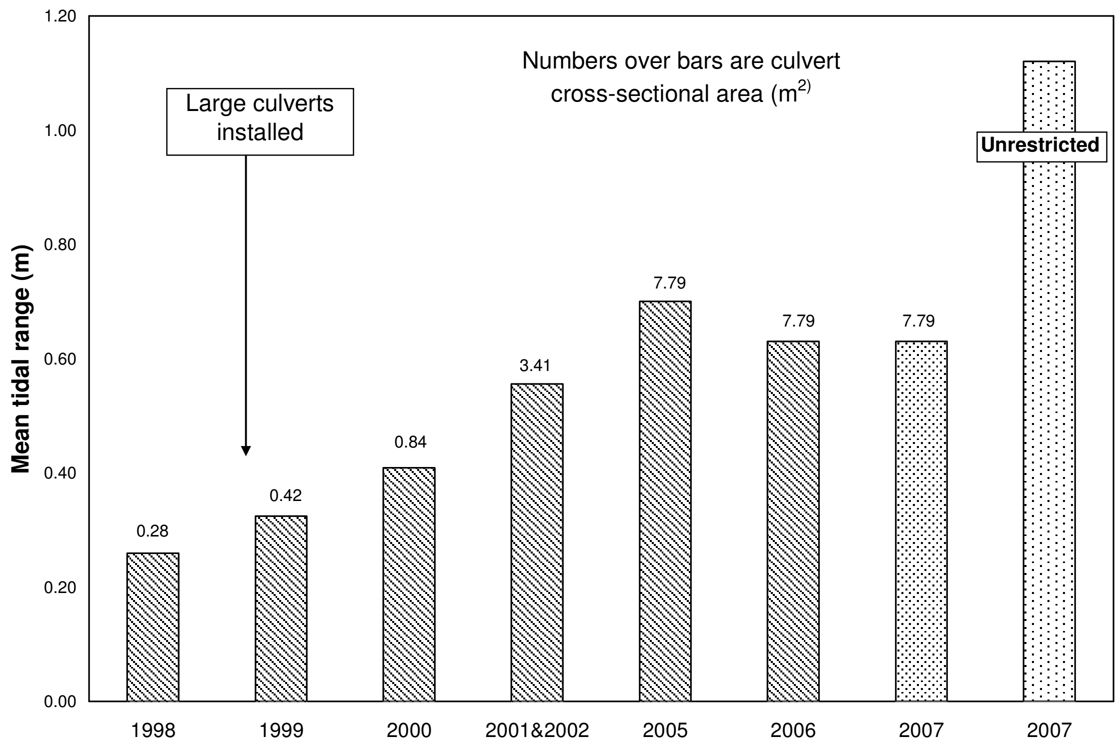


Figure 1-5. A summary of increases in mean tidal range in the diked marsh with incremental culvert opening, 1998 - 2007.



2. VEGETATION

STEPHEN SMITH

Background on methods

Previous data and methods can be found in the last annual report on Hatches Harbor vegetation monitoring (Gwilliam et al. 2007). A map of the permanent vegetation plots in Hatches Harbor is provided below (Figure 2-1). In 2007, only *Phragmites* stem heights and densities (all stems within $1m^2$ or $0.25m^2$ subplot) were determined in early October. *Phragmites* biomass was then estimated based on the equations of Thursby et al. (2002). Porewater salinities were also measured in each plot in samples taken from a depth of ~10 cm.

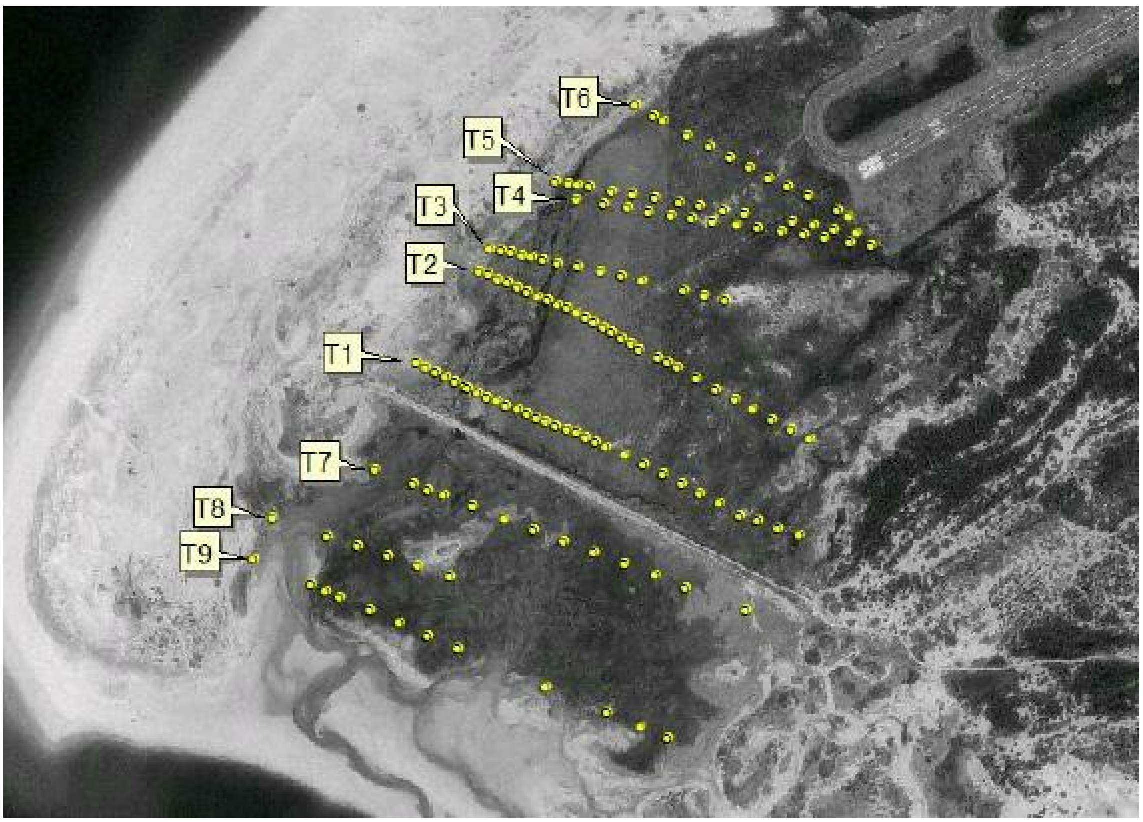


Figure 2-1. Map of Hatches Harbor permanent vegetation plots along nine transects.

Results

Phragmites – In plots where it existed in 2006, *Phragmites* showed numerous declines in mean stem height (Figure 2-2a). However, there were some plots where *Phragmites* had invaded since 2006 - generally at large distances away (upslope) from the tidal creek. This trend is amplified when data from 2002 and 2006 are compared (Figure 2-2b).

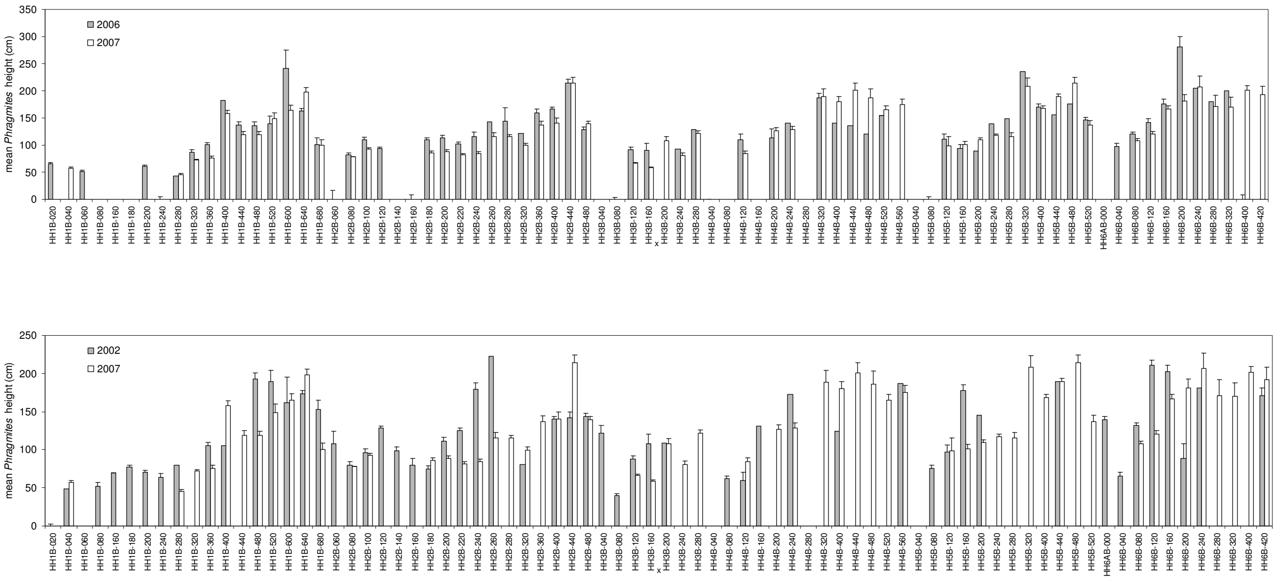


Figure 2-2. *Phragmites* stem heights (cm) by transect in 2006 vs. 2007 (above) and 2002 vs. 2007 (below).

The frequency with which *Phragmites* occurs in the plot network has shown little variation since 2002. *Phragmites* biomass (all plots pooled) was more variable than plot frequency among years and exhibited a slight, but non-significant decline between 2006 and 2007. Moreover, biomass values are statistically unchanged since 2002 (Fig. 2-3).

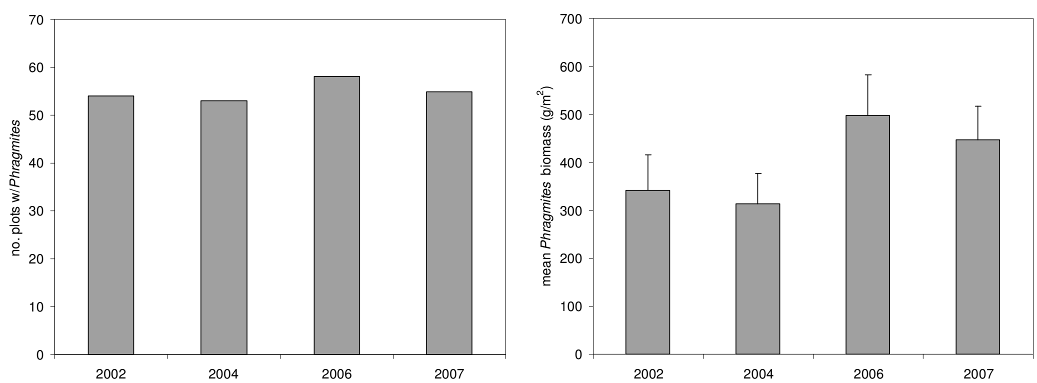


Figure 2-3. Number of plots with *Phragmites* by year (left) and *Phragmites* biomass (all plots pooled) (right) by year.

It is clear that the distribution of *Phragmites* continues to shift (Figure 2-4, 2-5). In general, *Phragmites* is still migrating upslope, away from the main tidal creek. This is apparently in response to saltier water penetrating farther into the marsh each year. As a result, *Phragmites* continues to decline at its seaward edge while advancing landward. It has been particularly successful invading areas where inter-specific competition is essentially absent due to recent mortality of salt-intolerant taxa.

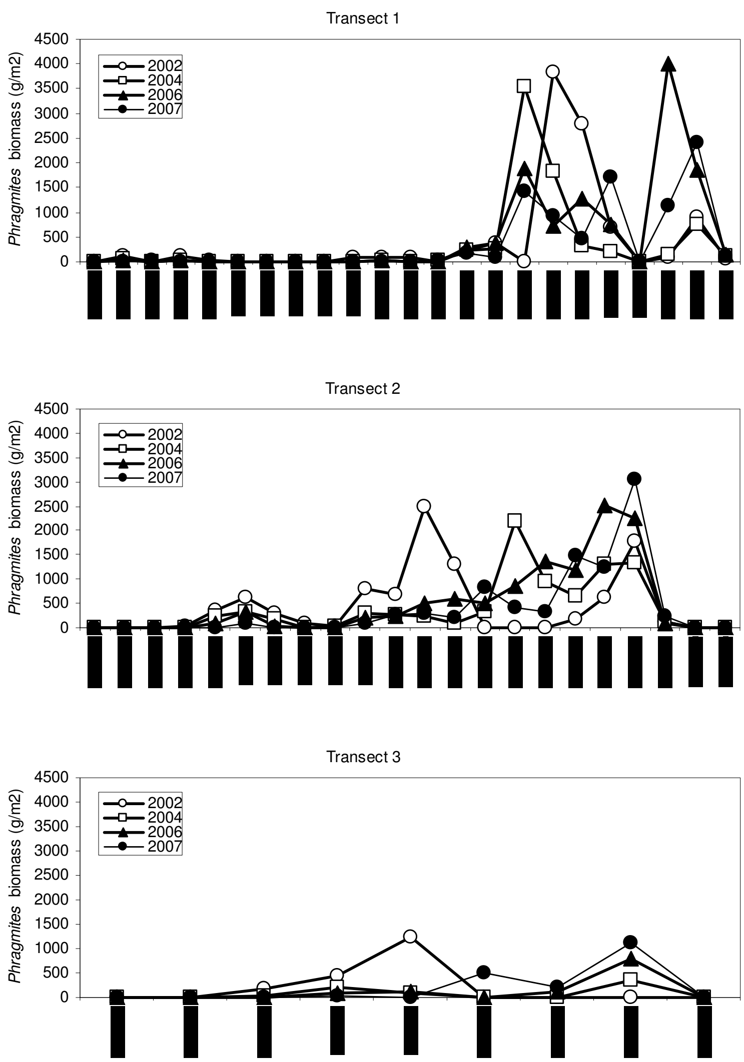


Figure 2-4. *Phragmites* biomass along transects 1-3 in 2002, 2004, 2006 and 2007.

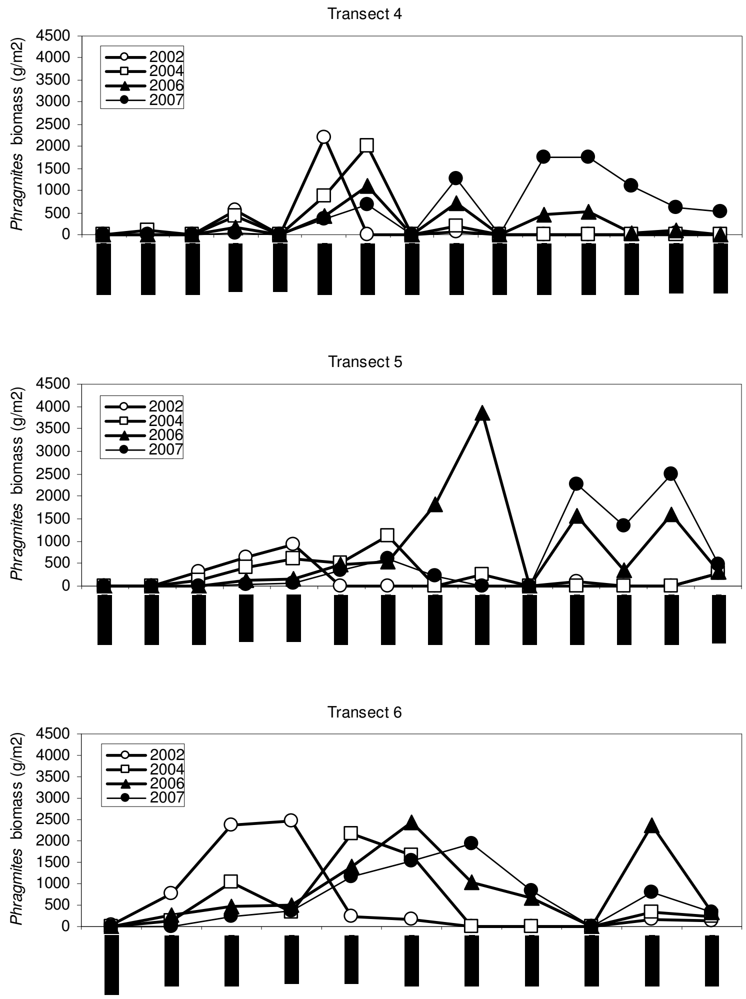


Figure 2-5. *Phragmites* biomass along transects 4-6 in 2002, 2004, 2006 and 2007.

Water chemistry - Compared with 2006, higher salinities can be found at greater distances from the tidal creek, especially along transects 4-6 (Figure 2-6). Although these data represent a single sampling event, and are therefore confounded to a certain extent by short-term fluctuations from rainfall and tidal cycles, they do correlate with observation on the ground. For example, where salinities are recently elevated there is typically evidence of the recent death of freshwater vegetation, most probably from salt intrusion.

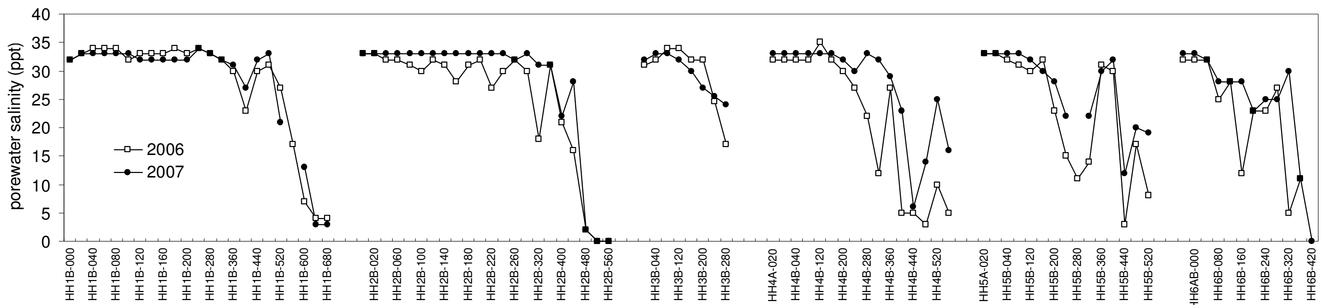


Figure 2-6. September porewater salinities (10-cm depth) by plot in 2006 vs. 2007.

Salinity anomalies occur in the 480-560 m range along transect 4, the 360-400 m range along transect 5, and at 320 m along transect 6. Along transects 5 and 6, these plots are within an area where the Provincetown Municipal Airport has repeatedly mowed *Phragmites*. Where this has occurred, salinities are elevated compared to those plots around them within unmanaged vegetation. This is noteworthy because there is no elevation anomaly associated with these peaks. In other words, salinities are not higher due to a decrease in elevation that traps salty water during high tides. Accordingly, these peaks are thought to reflect a decrease in water flow resistance across the marsh as a result of vegetation removal. This suggests that by cutting vegetation and creating conduits for water flow through the system, we have the ability to elevate salinity levels in certain sections of the marsh. The peak along transect 4 at plot 4B-520 is outside this management boundary. However, salt water can apparently find its way through to this area by natural pathways. There is also a plot along transect 4 (4B-360) that is within the management area. However, elevated salinities along most of this transect up to that point obscure any effect of vegetation removal on salinity there.

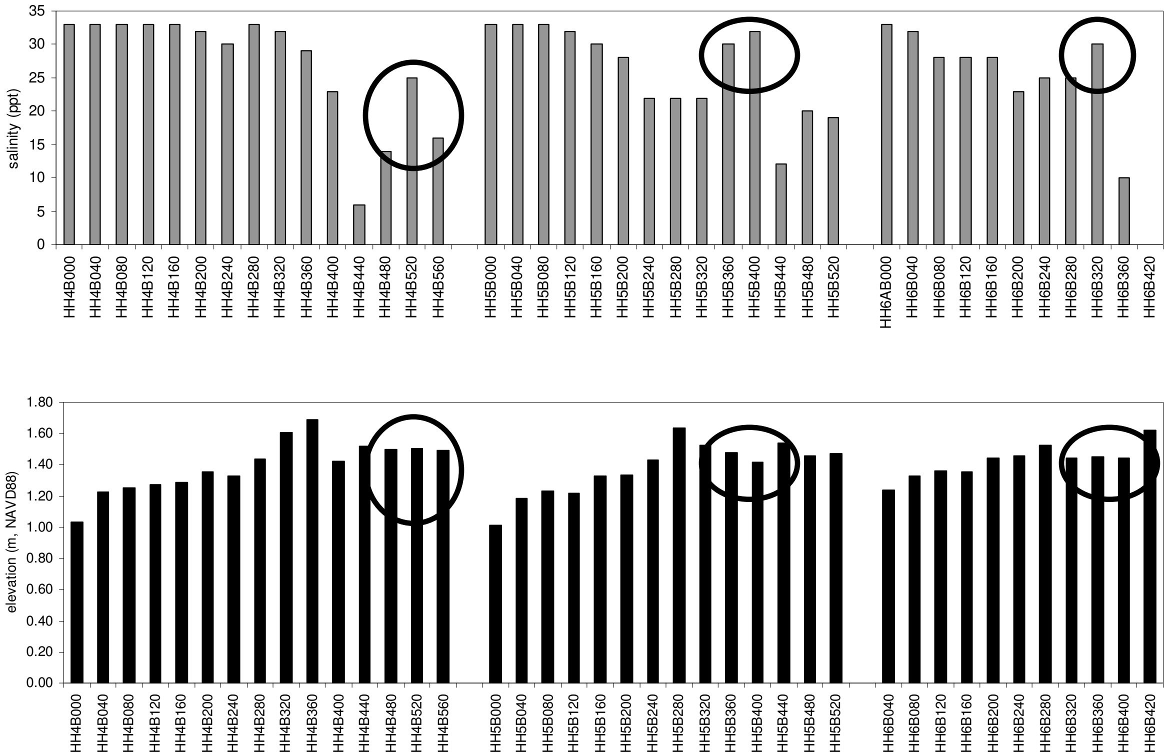


Figure 2-7. Porewater salinity (above) and ground elevation (below) by plot. Circled areas denote salinity peaks and their corresponding elevations.

Discussion

After seven years of progressively increasing seawater flow through the Hatches Harbor dike, there have been significant physico-chemical and floristic changes in the tide-restricted marsh (Smith et al. 2007). Overall, a 22% increase in tidal range was facilitated by the new culvert system. Although this seems rather small given the nearly 27-fold increase in the cross-sectional area of the dike opening, it translates to a much larger volume of water being spread out over a much greater area of marsh. The area of *Spartina*-dominated salt marsh vegetation in the tide-restricted marsh has expanded well beyond the estimated 5 ha that existed in 1995 (Portnoy et al. 2003) (Figure 2-8). With the exception of *Puccinellia distans*, which disappeared, the restricted side of Hatches Harbor has attained all species present in the unrestricted side within 7 years.

The degree to which species composition in the tide-restricted marsh resembled the tide-unrestricted marsh was most closely related to elevation and distance from the point of seawater entry (i.e., the culverts), both of which determine flood duration and long-term porewater salinity conditions. Exceptions include areas of isolated higher-elevation “islands” near the culverts that support upland taxa, as well as depressions in the interior marsh that still experience low salinities.

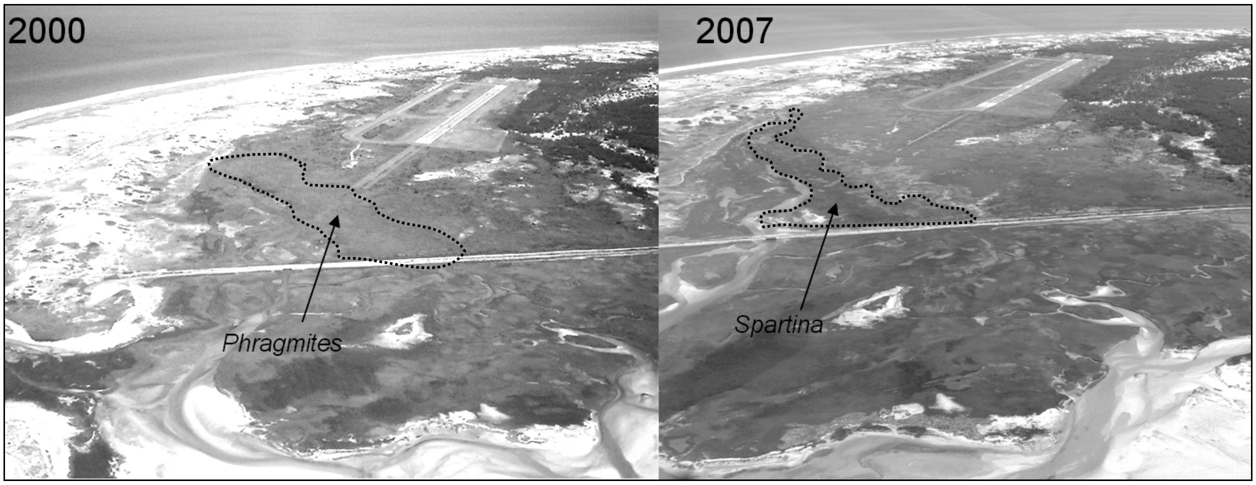


Figure 2-8. Photos of Hatches Harbor showing the change in vegetation adjacent to the main tidal creek upstream of the dike (2000-2007).

Further development of the salt marsh community upstream of the dike appears to be limited by the inability of seeds/propagules to move beyond the physical barrier of standing dead (salt killed) vegetation (Smith 2007). In their analysis of seed dispersal, Levine and Murrell (2003) suggest that the distribution of plant species is frequently regulated by factors that inhibit movement. Similarly, Wolters et al. (2005) pointed out the importance of seed sources and dispersal in northwestern Europe.

At Hatches Harbor, dead stems of *Phragmites* and woody shrubs trap wrack material and prevent the dispersal of seeds across a large portion of the tide-restricted marsh. Standing dead vegetation may also affect the dynamics of water flow through the marsh and, therefore, influence flood duration and/or salinity. As this dead plant material degrades, further shifts in vegetation are expected as seeds and propagules are able to penetrate farther into the marsh. However, there are certain ways in which this process may be helped. One has already happened – the re-creation of historic tidal creeks through the system. As shown in Figures 2-9a and 2-9b below, pockets of salt marsh have become established where the developing salt marsh adjacent to the main creek has been connected to open areas via pathways through the *Phragmites*, allowing for enhanced dispersal of seeds and propagules.

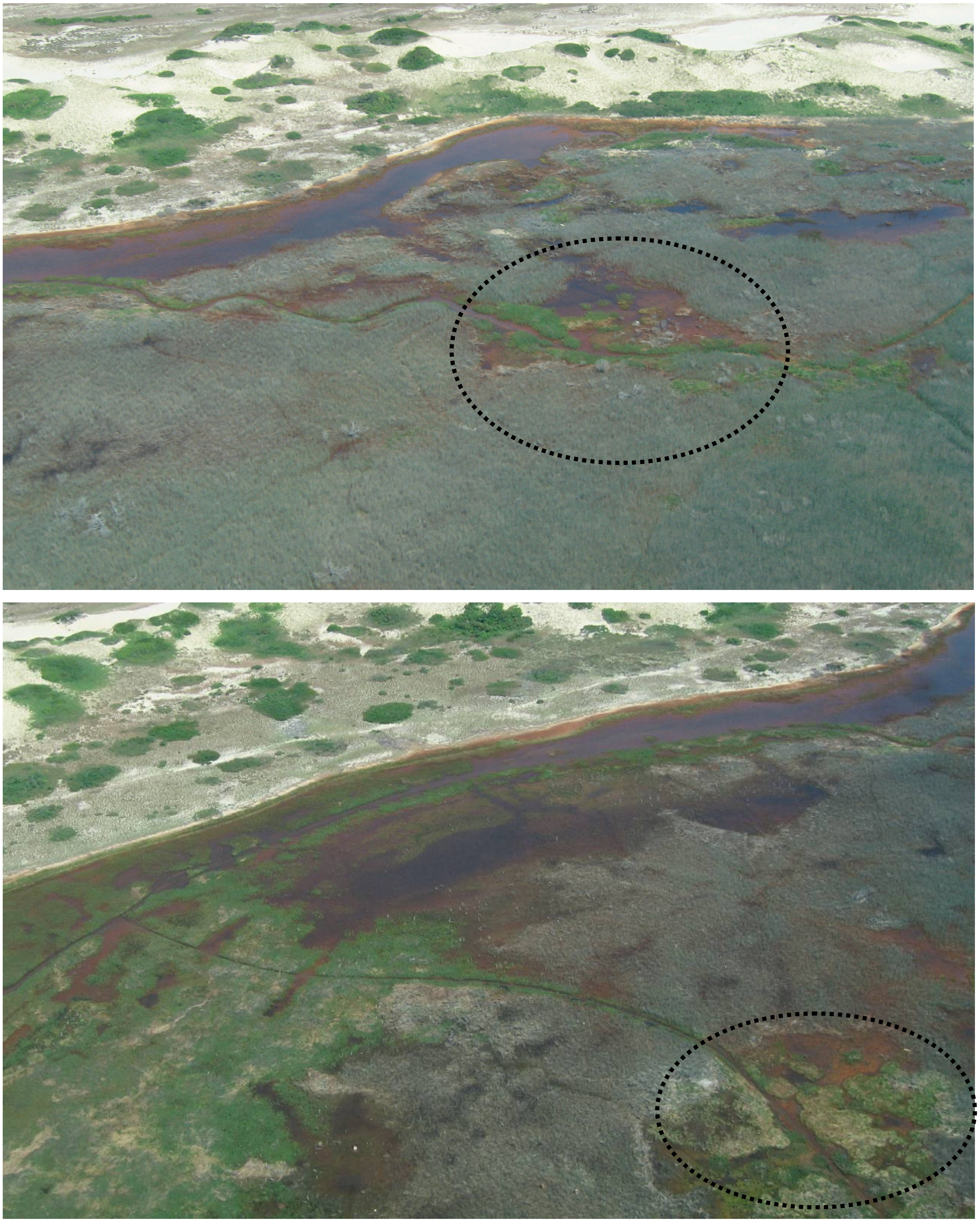


Figure 2-9. Photos showing the development of salt marsh plant communities (circled) in "holes" within the *Phragmites* population, and their connection to the main tidal creek via created pathways (photo taken June 2007).

Future work

- This winter (2006-2007), given suitable weather conditions, a prescribed burn will be conducted in the Phragmites-dominated areas of Hatches Harbor. The intent here is to decrease resistance to water flow across the marsh and enhance halophyte seed dispersal.
- In July-August 2008, all plots (both restricted and unrestricted) will be surveyed for plant community composition. In October, *Phragmites* stem densities and heights will be recorded as well as porewater salinity.

3. NEKTON (FISH AND DECAPOD CRUSTACEANS)

Introduction

Nekton is an effective and powerful sample population for monitoring the results of tidal restoration in the Hatches Harbor salt marsh, ongoing since spring 1999. Changes in nekton abundance, density and species composition reflect perturbations in multiple ecosystem processes that would be too difficult or costly to monitor individually. Nekton responds rapidly to ecological changes, especially to changes in hydrology, i.e., increasing tidal range in the restricted area of Hatches Harbor. They also respond to disturbances in food chain dynamics from the bottom up, e.g. removal/change in primary producer populations by anthropogenic impact to estuarine water quality, or from the top down, e.g., removal of predators; this important attribute may not be present in other sample populations (Raposa and Roman 2001a).

Since the reintroduction of tidal flow into the restricted section of the Hatches Harbor marsh, the nekton community has responded to increased tidal range and salt marsh habitat. Nekton community structure in creeks and pools has shifted to more closely resemble the unrestricted portion of the system seaward of the dike (Portnoy et al. 2003; Portnoy et al. 2005).

This is a report on nekton abundance and diversity data collected in July and September of 2007 in the Hatches Harbor salt marsh using throw traps in pools and creeks. Throw traps yield repeatable and quantifiable measures of nekton density (Rozas and Minello 1997).

Methods

Sample Design

Nektons were sampled at randomly selected stations in creeks and pools within each sample site (i.e., Hatches Harbor Restricted sample site and Hatches Harbor Unrestricted sample site). Sampling with throw traps was attempted twice during the 2007 season at sixty sites distributed in creeks and pools. However, because many stations had no standing water, only 24 and 22 stations were actually sampled during July and September sampling events, respectively ember (Table 3-1).

Use of lift nets in the new creeks in the restricted portions of the marsh could not be completed this year due to a lack of suitable sampling conditions. Unlike sampling in 2006, these creeks were mostly dry or flooded over their banks during low tide, making sampling with lift traps impossible.

	Creek (throw trap)	Pool	Marsh Surface	Creek (lift net)
Restricted	14/12	3/1	No Data	No Data
Unrestricted	9/9	0/0	No data	No Data

Table 3-1. Number of sample stations by type and habitat strata. The first number is for number of stations sampled in June, second is for September.

Sampling Period
Sampling was conducted twice (18-24 July and 18-19 September) in 2007. Each sampling session was conducted over several days, in bouts lasting four to six hours. All data were collected during low tide periods when all water was off the marsh surface.

Data analysis
For each year, we report the number of animals sampled, number of species, their relative abundance, and mean and standard deviation of nekton density and length. In 2005 to 2007, when there were two samples collected from each sample station, average densities and lengths from these two annual samples is used for analysis. Trend analysis using the Pearson's correlation coefficient (alpha=0.05) was applied to data for species diversity and density of all nekton, crustaceans, fish and selected individual species using the XLSTAT software package (Sokal and Rohlf 1981).

Results and Discussion
During the 2007 sample period, three species of fish and three of crustaceans were collected (Table 3-2), with the common mummichog (*Fundulus heteroclitus*) the dominant fish species and the sand shrimp (*Crangon septemspinosa*) the dominant crustacean (Table 3-3). Similar to past years, the sand shrimp was found most commonly in the wide, shallow sandy creeks of the unrestricted portion of the marsh, while the mummichog was encountered most commonly on the restricted side where there was shelter, such as under the eroded creek banks, close at hand. This is typical of northeastern salt marsh systems. At Hatches Harbor, as the main creek in the restricted sample area gradually becomes wider and sandier bottomed as the result of restored tidal flow, the sand shrimp has increased in relative abundance (with a corresponding decrease in *F. heteroclitus* relative abundance), and experienced a ten-fold increase in density (0.3 to 3.0 animals/m^2) (Table 3-4).

There was no significant change in nekton density (Figure 3-1, Table 3-4) and number of species (Table 3-2) in creeks but 2 new species were sampled on the unrestricted side, the long wrist hermit crab (*Pagurus longicarpus*) and the Atlantic menhaden (*Brevoortia tyrannus).* Both species are common in coastal and estuarine waters. There was an apparent decrease in nekton density (Figure 3-2) and number of species (Table 3-2) in pools in 2007 compared to previous years; however, none of these trends are significant (alpha = 0.05), likely due to the small sample size.

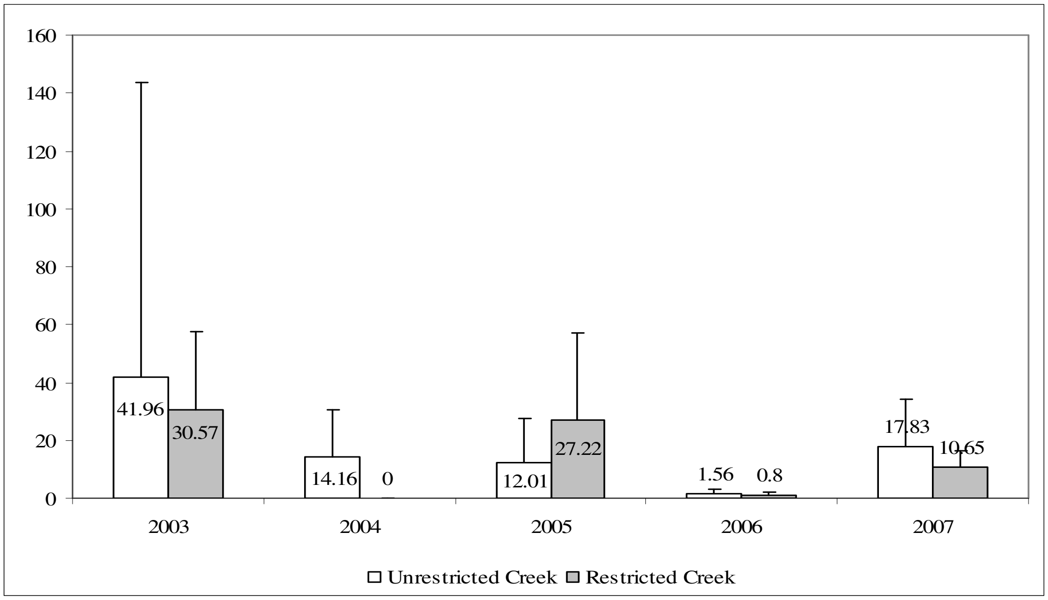


Figure 3-1. Mean total nekton density in creek habitat strata 2003 to 2007. Numbers on bars are density values, error bars indicate standard deviation.

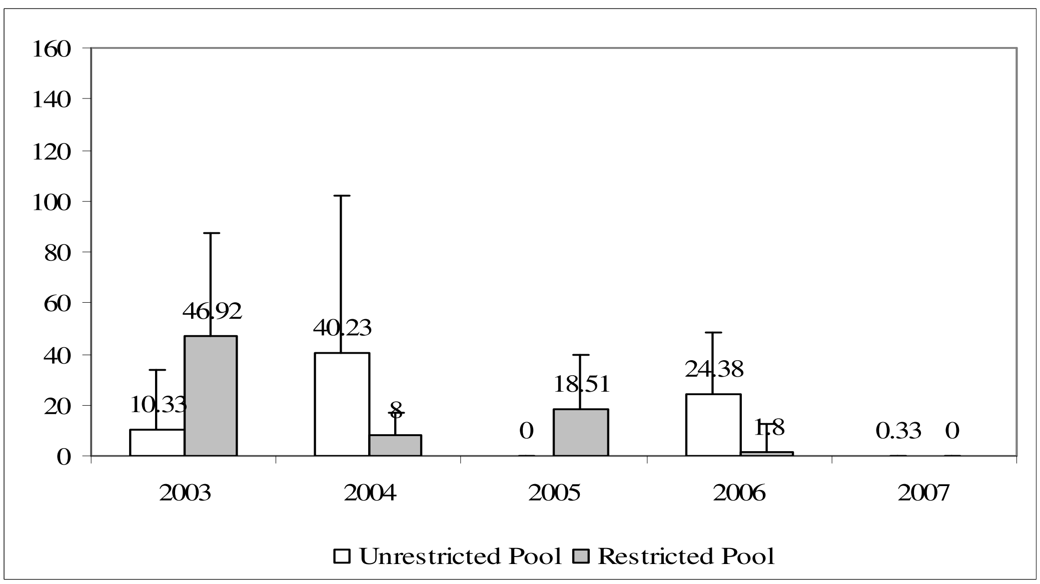


Figure 3-2. Mean total nekton density in pool habitat strata 2003 to 2007. Numbers on bars are density values, error bars indicate standard deviation.

Water temperature was generally cooler in the creeks (~18º C) than in the restricted pools (~22º C). Dissolved oxygen was also lower in the restricted creek, expected with a higher proportion of high-oxygen-demand wetland runoff. Also expectedly, salinity decreased slightly with distance from the source of tidal water: ~33 ppt on the unrestricted side to ~32 ppt on the restricted side (Table 3-5).

Conclusion

The restoration of Hatches Harbor is having a positive effect on the nekton community by greatly increasing the area of habitat, as documented by this and previous Hatches Harbor Annual reports. The increase in habitat provides new areas that are used as nursery areas and for feeding and breeding. The results that were collected from 2003 to 2007 will be used to learn more about the response of nekton to the restoration process and will be used to refine the monitoring protocol to make future sampling more effective. The work in 2007 focused on continuing implementation of the nekton monitoring protocol with the following conclusions:

- Hatches Harbor is a dynamic estuarine system with a nekton community typical of Lower Cape estuaries; in 2007 mummichog, sand shrimp, green crab, Atlantic silverside and two new species; long wrist hermit crab and Atlantic menhaden, were sampled.
- In the restricted marsh, increased tidal range and new creeks allow nekton access to a greater area of habitat.
- Increase in habitat area, changes in creek and wetland morphology and perhaps other unknown variables have resulted in decreased effectiveness of sampling methods (e.g. nekton are staying on the marsh surface and not returning to the creeks at low tide).

Future work will include:

- Continued annual sampling in pools, creeks and on the marsh surface.
- Testing of new methods to increase effectiveness of monitoring in Hatches Harbor. The use of lift nets, while not effective in 2007 due to changing marsh hydrology and unsuitable sampling conditions, will be attempted again in 2008.

	2003				2004				2005				2006							2007			
	R		U		R		U		R		U		R				U			R		U	
Species	C	P	C	P	C	P	C	P	C	P	C	P	C[1]	C[2]	MS	P	C	MS	P	C	P	C	P
American eel									X				X										
Green crab				X			X	X	X	X	X		X	X	X		X	X	X	X		X	
Sand shrimp			X				X	X	X	X	X		X				X			X	X	X	
Sheepshead minnow	X																						
Mummichog	X	X	X	X		X	X	X	X	X	X		X	X		X	X		X	X		X	
Striped killifish		X	X	X		X	X		X		X												
Atlantic silverside							X	X	X		X									X		X	
White perch									X														
Shore shrimp	X		X																				
Winter flounder							X		X		X												
Long wrist hermit crab																						X	
Menhaden																						X	
Total species	3	2	4	3	0	2	6	4	8	3	6	0	4	2	1	1	3	1	2	4	1	6	0

Table 3-2. Species sampled at Hatches Harbor 2003 to 2007. R-restricted area of marsh; U-unrestricted area of marsh; C[1]-creek habitat >1m wide; C[2]-creek habitat <1m wide; P-pool habitat; MS-marsh surface habitat

	Unrestricted Creek	Restricted Creek	Unrestricted Pool	Restricted Pool
Fish	19	69		
Decapod	81	31		
Brevoortia tyrannus	0	0		
Carcinus maenas	1	1		
Crangon septemspinosa	79	30		100
Fundulus heteroclitus	16	67		
Menidia menidia	3	2		
Pagurus longicarpus	1	0		

Table 3-3. Relative abundance (percent) of nekton by habitat strata and sample area

	Hatches Harbor Restricted Creek Nekton Density				
	2003	2004	2005	2006	2007
TOTAL DECAPOD	0.86 ± 2.27 (6)	NO DATA	6.2 ± 9.84 (371)	0.3 ± 0.84 (10)	3.13 ± 1.94 (84)
TOTAL FISH	38.93 ± 43.23 (282)		43.41 ± 56.81 (1950)	1.27 ± 2.83 (38)	7.53 ± 7.62 (185)
TOTAL NEKTON	30.57 ± 26.81 (288)		27.22 ± 29.96 (2321)	0.8 ± 1.42 (48)	10.65 ± 5.67 (269)
Anguilla rostrata			0.03 ± 0.18 (1)	0.07 ± 0.25 (2)	
Carcinus maenas			0.16 ± 0.58 (8)	0.3 ± 0.84 (9)	0.12 ± 0.07 (3)
Crangon septemspinosa			8.95 ± 21.52 (363)	0.03 ± 0.18 (1)	3.01 ± 2.01 (81)
Cyprinodon variegatus	0.14 ± 0.38 (1)				
Fundulus heteroclitus	40.14 ± 42.38 (281)		51.23 ± 59.63 (1914)	1.2 ± 2.85 (36)	7.28 ± 7.26 (179)
Fundulus majalis			0.52 ± 1.75 (16)		
Menidia menidia			0.48 ± 1.91 (15)		0.5 ± 0 (6)
Morone americana			0.03 ± 0.18 (1)		
Palaemonetes spp.	0.86 ± 2.27 (6)				
Pseudopleuronectes americanus			0.1 ± 0.3 (3)		

Table 3-4a. Mean nekton density (animals/m^2) in restricted creek area from 2003-2007.

	Hatches Harbor Unrestricted Creek Nekton Density				
	2003	2004	2005	2006	2007
TOTAL DECAPOD	2.63 ± 3.86 (42)	17.5 ± 24.34 (318)	12.54 ± 19.24 (528)	2.2 ± 4.93 (58)	14.39 ± 15.01 (259)
TOTAL FISH	45.28 ± 102.15 (762)	2.36 ± 2.79 (40)	5.08 ± 8.15 (169)	0.64 ± 2.36 (14)	3.44 ± 1.26 (62)
TOTAL NEKTON	41.96 ± 101.98 (804)	14.6 ± 16.36 (358)	12.01 ± 15.42 (697)	1.56 ± 2.75 (72)	17.83 ± 16.26 (321)
Brevoortia tyrannus					0.11 ± 0 (1)
Carcinus maenas		0.14 ± 0.32 (3)	0.45 ± 1.01 (12)	0.64 ± 1.94 (14)	0.22 ± 0 (2)
Crangon septemspinosa	0.31 ± 1.01 (5)	21.14 ± 30.76 (315)	15.75 ± 24.04 (516)	2 ± 5.35 (44)	14.17 ± 14.69 (255)
Fundulus heteroclitus	46.19 ± 101.91 (739)	2.55 ± 4.16 (28)	3.91 ± 6.72 (86)	0.64 ± 2.36 (14)	2.83 ± 1.81 (51)
Fundulus majalis	1.44 ± 3.22 (23)	0.18 ± 0.4 (3)	0.95 ± 4.05 (21)		
Gasterosteus aculeatus					
Menidia menidia		0.45 ± 1.21 (5)	2.68 ± 11.03 (59)		0.56 ± 0.63 (10)
Pagurus longicarpus					0.22 ± 0 (2)
Palaemonetes spp.	2.31 ± 3.93 (37)				
Pseudopleuronectes americanus		0.36 ± 1.21 (4)	0.14 ± 0.47 (3)		

Table 3-4b. Mean nekton density (animals/m^2) in unrestricted creek area 2003-2007.

	Hatches Harbor Restricted Pool Nekton Density				
	2003	2004	2005	2006	2007
TOTAL DECAPOD			3 ± 4.5 (43)		0.33 ± 0 (0)
TOTAL FISH	46.92 ± 40.25 (341)	8 ± 9.17 (24)	25.69 ± 28.24 (207)	5.6 ± 11.53 (84)	
TOTAL NEKTON	46.92 ± 40.25 (341)	8 ± 9.17 (24)	18.51 ± 21.13 (250)	4.8 ± 10.65 (84)	0.33 ± 0 (1)
Carcinus maenas			0.13 ± 0.35 (1)		
Crangon septemspinosa			3.63 ± 5.26 (42)		0.33 ± 0 (1)
Fundulus heteroclitus	56.33 ± 49.36 (338)	2 ± 3.46 (6)	25.69 ± 28.24 (207)	5.6 ± 11.53 (84)	
Fundulus majalis	0.5 ± 1.22 (3)	6 ± 10.39 (18)			

Table 3-4c. Mean nekton density (animals/m^2) in restricted pools 2003-2007

	Hatches Harbor Unrestricted Pool Nekton Density				
	2003	2004	2005	2006	2007
TOTAL DECAPOD	0.2 ± 0.45 (1)	0.27 ± 0.65 (4)	NO DATA	0.25 ± 0.46 (2)	NO DATA
TOTAL FISH	15.4 ± 34.44 (154)	40.18 ± 61.96 (442)		36.38 ± 45.83 (291)	
TOTAL NEKTON	10.33 ± 23.11 (155)	40.23 ± 61.92 (446)		24.38 ± 23.91 (293)	
Carcinus maenas	0.2 ± 0.45 (1)	0.27 ± 0.65 (3)		0.25 ± 0.46 (2)	
Crangon septemspinosa		0.09 ± 0.3 (1)			
Fundulus heteroclitus	30.6 ± 68.42 (153)	40 ± 62.08 (440)		36.38 ± 45.83 (291)	
Fundulus majalis	0.2 ± 0.45 (1)				
Menidia menidia		0.18 ± 0.6 (2)			

Table 3-4d. Density and number of species sampled by habitat strata and sample area. First number is the mean density (nekton/m2) followed by the standard deviation of the mean. The number in parenthesis is the total number of type (decapod or fish) of nekton species sampled.

	Unrestricted	
	Creek	Pool
Temperature (C)	19.03 ± 4.83	No data
Salinity (ppt.)	33.22 ± 0.42	
Dissolved oxygen (mg/L)	7.95 ± 1.19	

	Restricted	
	Creek	Pool
Temperature (C)	17.67 ± 1.02	21.8 ± 0.75
Salinity (ppt.)	32.24 ± 1.1	32.17 ± 1.37
Dissolved oxygen (mg/L)	5.84 ± 1.91	6.5 ± 2.33

Table 3-5a,b Environmental variables for Hatches Harbor marsh by habitat strata and sample area for 2007.

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Appendix A

Correspondence and data regarding the breach of the berm Seaward of Runway 7

United States Department of the Interior

NATIONAL PARK SERVICE
Cape Cod National Seashore
99 Marconi Site Road
Wellfleet, MA 02667
HQ 508.349.3785
HQ Fax 508.349.9052
Lab 508.487.3262
Lab Fax 508-487-7153

Provincetown Airport Commission
Michael Leger, Chairman
Race Point Road,
Provincetown, MA 02657

19 July 2007

Dear Commissioners:

This is to transmit water-level data collected by my staff this spring, in cooperation with Airport Manager Butch Lisenby, to assess the effects of a breach in the flood-protection berm seaward of Runway 7 on surface water levels. You will recall that under the 1997 agreement between the Town and the Seashore for the Hatches Harbor Salt Marsh Restoration Project, the NPS took responsibility for building and maintaining this berm to avoid tidal flooding of the ILS reflectance area.

The earthen berm was damaged and repaired during the construction of the catwalk associated with a general upgrade of the ILS system several years ago. Unfortunately, the contractor who installed the catwalk also removed peat that supported and stabilized the original earthen berm built by NPS. As a result, that portion of the berm that passed under the catwalk was prone to slumping and consequent overtopping and erosion by high tides.

According to Mr. Lisenby, a major breach in the berm developed last summer; our staff first observed it last fall. The issue was discussed at the annual meeting of the Hatches Harbor Review Committee meeting in February (minutes attached), where it was decided to allow the breach to remain open until the Airport and we could monitor the effects on surface water flooding near the reflectance area.

We used an automated data logger to obtain water-level data in a well at the northeast corner of the wetland just seaward of Runway 7 (Figure1). The logger was deployed from 12 March to 19 April, and again from 8 May to 17 June 2007. The elevation (m-NAVD88) of the well-casing measuring point was determined by differential leveling from a bronze disk east of Runway 7 (northing 4658198; easting 398517; elevation= 1.695 determined by RTK GPS). Thus water level and land surface data for both deployments are presented relative to NAVD88 in Figures 2.

To summarize, the breach in the earthen berm has not resulted in flooding of the airport reflectance area. Fortuitously, the situation was given an extreme test in mid-April when a severe northeast storm hit the Cape during a period of spring tides. Precipitation exceeded 2.6 inches and tide heights (recorded by the Boston NOAA tide station) reached 14 feet MLLW. Even during this extreme event, surface water from Hatches Harbor did not reach the reflectance area (Fig. 2).

We have shared and discussed these data with Mr. Lisenby, who suggests that airport management may be satisfied that the earthen berm is no longer necessary to protect the airport instrument landing system. Therefore, unless there is further discussion, NPS will not attempt to repair the berm breach.

Finally, I believe that this small collaborative project serves as an excellent example of how Seashore and Airport managers have been able to work together so well over the past ten years to achieve both flood protection for the airport and salt-marsh restoration at Hatches Harbor.

Sincerely,

George E. Price, Jr.
Superintendent

CC:
Provincetown Town Manager

Provincetown BOS

Richard Doucette, Federal Aviation Administration, 12 New England Executive Park, Burlington, MA 01803

Mathew DeSorbo, Mass Aeronautics Commission, Ten park Plaza, Room 6620, Boston, MA 01226-3966

Butch Lisenby, Provincetown Airport, Race Point Road, Provincetown, MA 02657

Jim Mahala, DEP, 20 Riverside Drive, Lakeville, MA 02347

Figure 1. Relative locations of earthen berm, ILS reflectance area, and NPS observation well used to monitor surface water levels adjacent to Runway 7, Provincetown Airport.

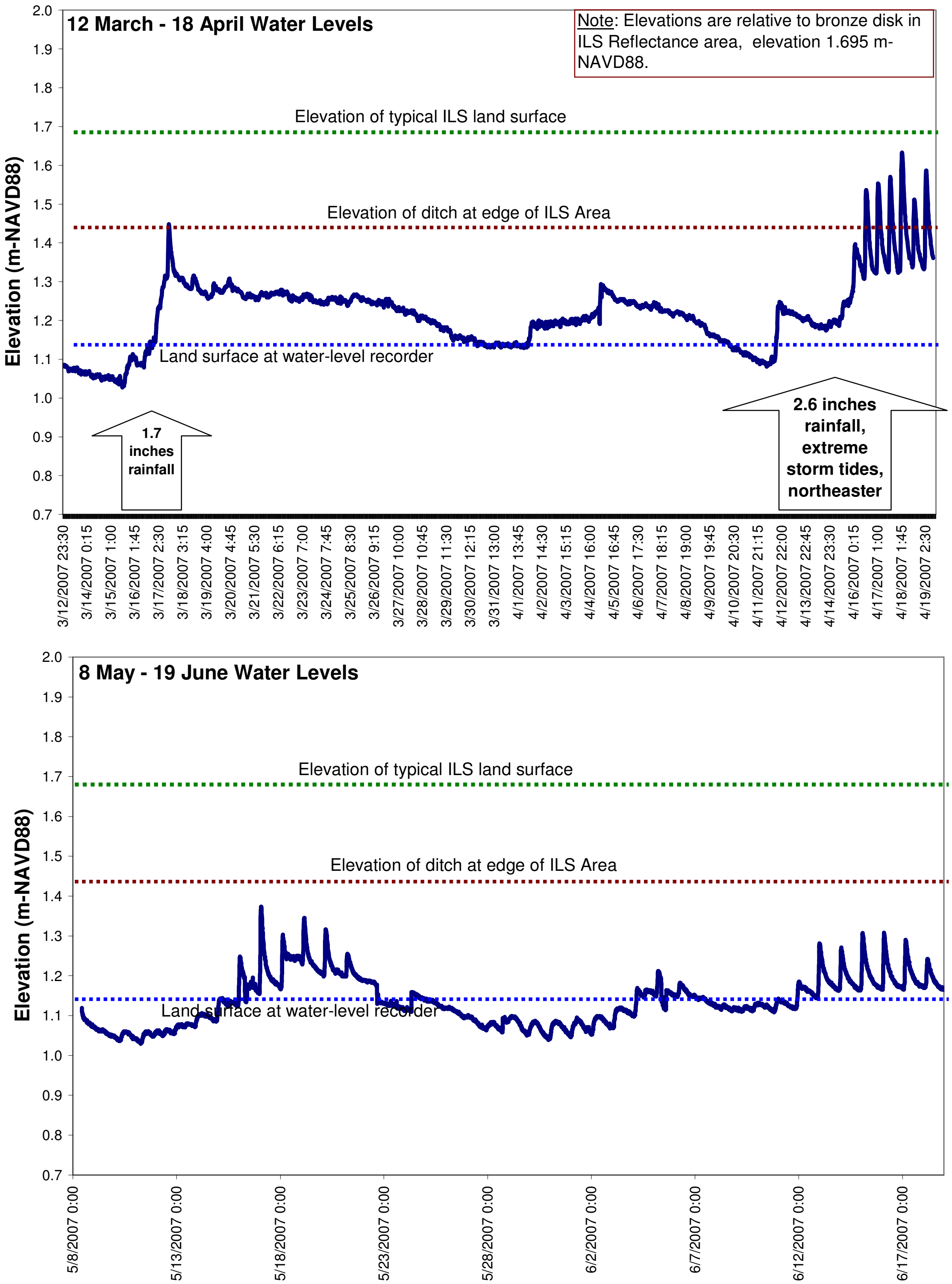

Figure 2. Water levels behind the breached earthen berm seaward of Provincetown Airport Runway 7, relative to elevations of the ILS reflectance area.

27 February 2007

Minutes of Hatches Harbor Technical Review Committee meeting

Attendees: Stephen Smith (NPS), Butch Lisenby (Provincetown Airport), Evan Gwilliam (NPS), Richard Doucette (FAA, by speaker phone), Jim Mahala (DEP), Matthew DeSorbo (MAC), Carrie Phillips (NPS), Graham Giese (Provincetown Center for Coastal Studies), Gabrielle Sakolsky (CCMCP), Dennis Minsky (Provincetown Conservation Commission), David Crary (NPS) and John Portnoy (NPS).

Cape Cod National Seashore staff Smith, Gwilliam and Portnoy presented a summary of 2006 tide-height, vegetation and nekton monitoring results. A full report on this monitoring was sent to all members prior to the meeting.

D. Minsky asked about northern harrier use of the floodplain. There are usually 1-2 pairs of these raptors using the restoration area above the dike. Two reports by Seashore cooperators are in preparation.

Smith and Crary described plans for a prescribed burn of Phragmites and salt-killed shrubs this fall seaward of the airport approach. The purpose is to clear away standing vegetation that impedes the spread of wrack and seeds of salt-marsh plants. Preferred wind direction for smoke control would be from the northwest to northeast. The Seashore will coordinate with Airport authorities to ensure that this project does not create an aviation safety hazard.

J. Portnoy reported on the condition of structures whose maintenance is the responsibility of the Seashore. The culvert aprons, which began to erode in summer 2005, were repaired with the addition of much larger stones in March 2006. The aprons now appear stable but will be monitored regularly by park staff.

The earthen berm at the airport approach breached under the catwalk, reportedly (Lisenby) last summer. Portnoy noted that during construction of the catwalk, the berm was weakened and underlying peat was removed, making the berm more prone to breaching. He also noted that this peat removal created a linear pond all along the length of the catwalk which attracts waterfowl, a safety hazard to aircraft. In this regard, the breach is beneficial in improving low-tide drainage and limiting the time that the new “pond” is flooded and attractive to ducks.

B. Lisenby stated that the FAA still maintains that the berm is needed to protect the airport approach system; however, that agency and the airport are willing to tolerate the breach at least over the short term to reassess the need for the berm. Airport authorities will notify the Seashore if tidal flooding becomes a problem at the end of Runway 7 and within the ILS reflectance area to the southwest of the runway. Portnoy offered to install a water-level recorder in the area of concern; he and Lisenby will meet soon to plan this monitoring.

As agreed at last year’s TRC meeting, we hereafter switch to a biennial schedule, with the next meeting planned for winter of 2008-9. Nevertheless, the Seashore will continue to produce annual reports on the progress of the restoration project.

Respectfully submitted,

John Portnoy